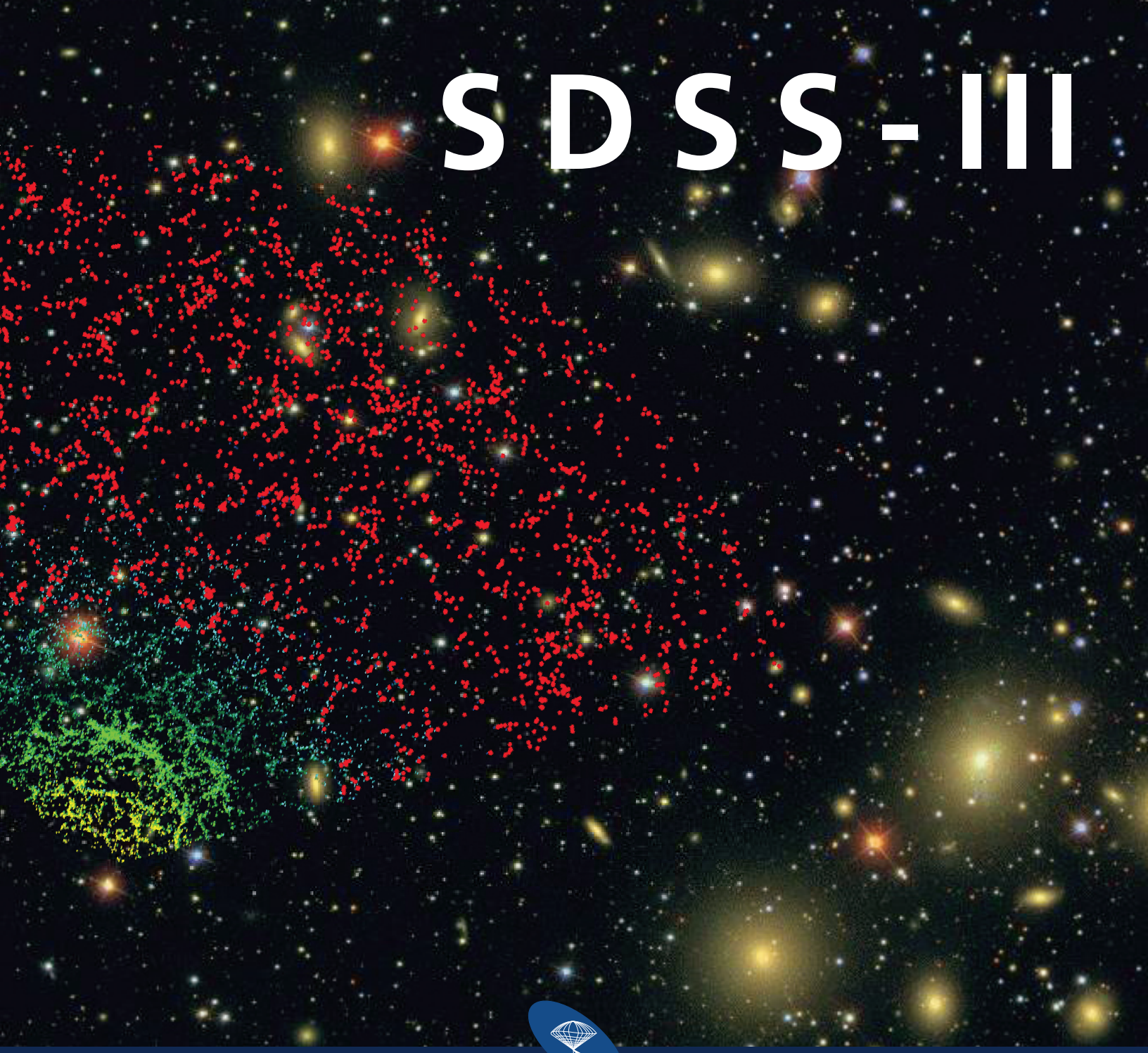
SDSS-III



SLOAN DIGITAL SKY SURVEY

SDSS-III

Massive Spectroscopic Surveys of the Distant Universe, the Milky Way Galaxy, and Extra-Solar Planetary Systems

www.sdss3.org

The APO 2.5-m telescope at sunset.
Credit: D. Kirkby

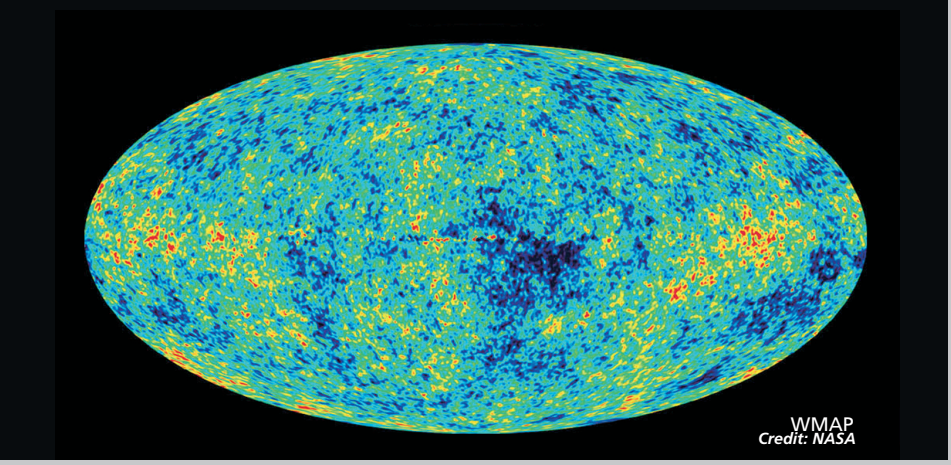
SLOAN DIGITAL SKY SURVEY

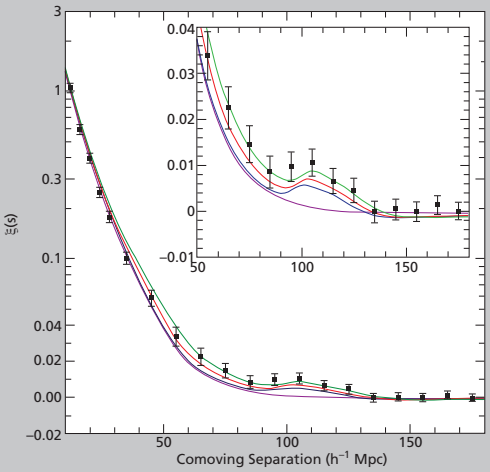
SDSS-III

Building on the legacy of the Sloan Digital Sky Survey (SDSS) and SDSS-II, the SDSS-III Collaboration will carry out a program of four surveys on three scientific themes: dark energy and cosmological parameters, the structure, dynamics, and chemical evolution of the Milky Way, and the architecture of planetary systems.

Over the course of six years (2008-2014), these four surveys will exploit the unique wide-field spectroscopic capability of the Apache Point Observatory's 2.5-meter telescope. BOSS will measure the cosmic distance scale via clustering in the large-scale galaxy distribution and the Lyman-α forest. SEGUE-2 and APOGEE will map the structure, kinematics, and chemical evolution of the Milky Way via optical and infrared spectra of stars across the full range of the Galactic bulge, disk, and halo. MARVELS will probe the population of giant planets via radial velocity monitoring of 11,000 stars. SDSS-III will continue the SDSS tradition of public data releases, with the first release scheduled for summer 2010.

The SDSS-III Collaboration is forming now, and it is expected to include more than 20 institutions from around the globe. Inquiries from interested parties are welcome (see www.sdss3.org for information). The Alfred P. Sloan Foundation has conditionally approved a generous grant to initiate the project, and additional funds are being sought from federal agencies and the participating institutions.





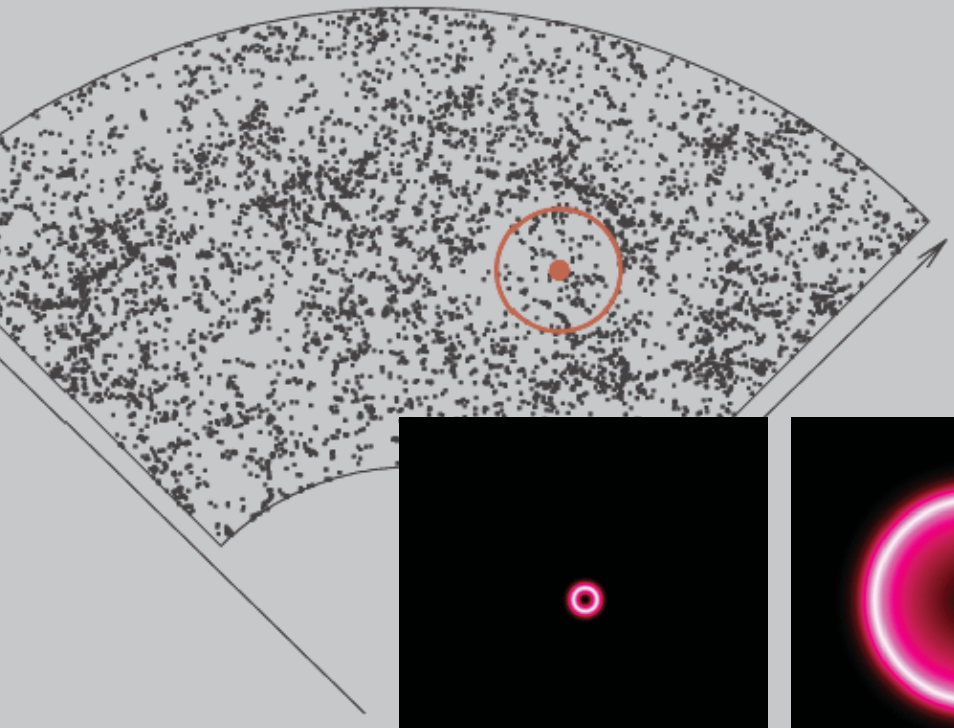
Sound waves that propagate in the early universe, like spreading ripples in a pond, imprint a characteristic scale on cosmic microwave background fluctuations (above left). This scale can be identified as a bump in the correlation function (above right) measured from the map of luminous galaxies in the SDSS (bottom of page).

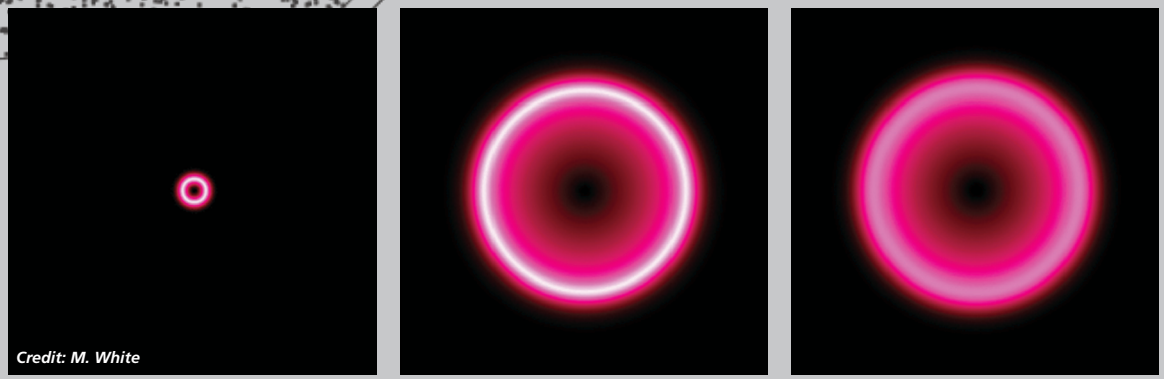
The Baryon Oscillation Spectroscopic Survey will map the spatial distribution of luminous galaxies and intergalactic hydrogen absorption towards high-redshift quasars to detect the characteristic scale imprinted by baryon acoustic oscillations in the early universe. Using the acoustic scale as a physically calibrated ruler, BOSS will determine the angular diameter distance with precision of 1% at redshifts z = 0.3 and z = 0.6 and 1.5% at z = 2.5, and it will measure the cosmic expansion rate H(z) with 1-2% precision at the same redshifts. These measurements will provide demanding tests for theories of dark energy and the origin of cosmic acceleration.

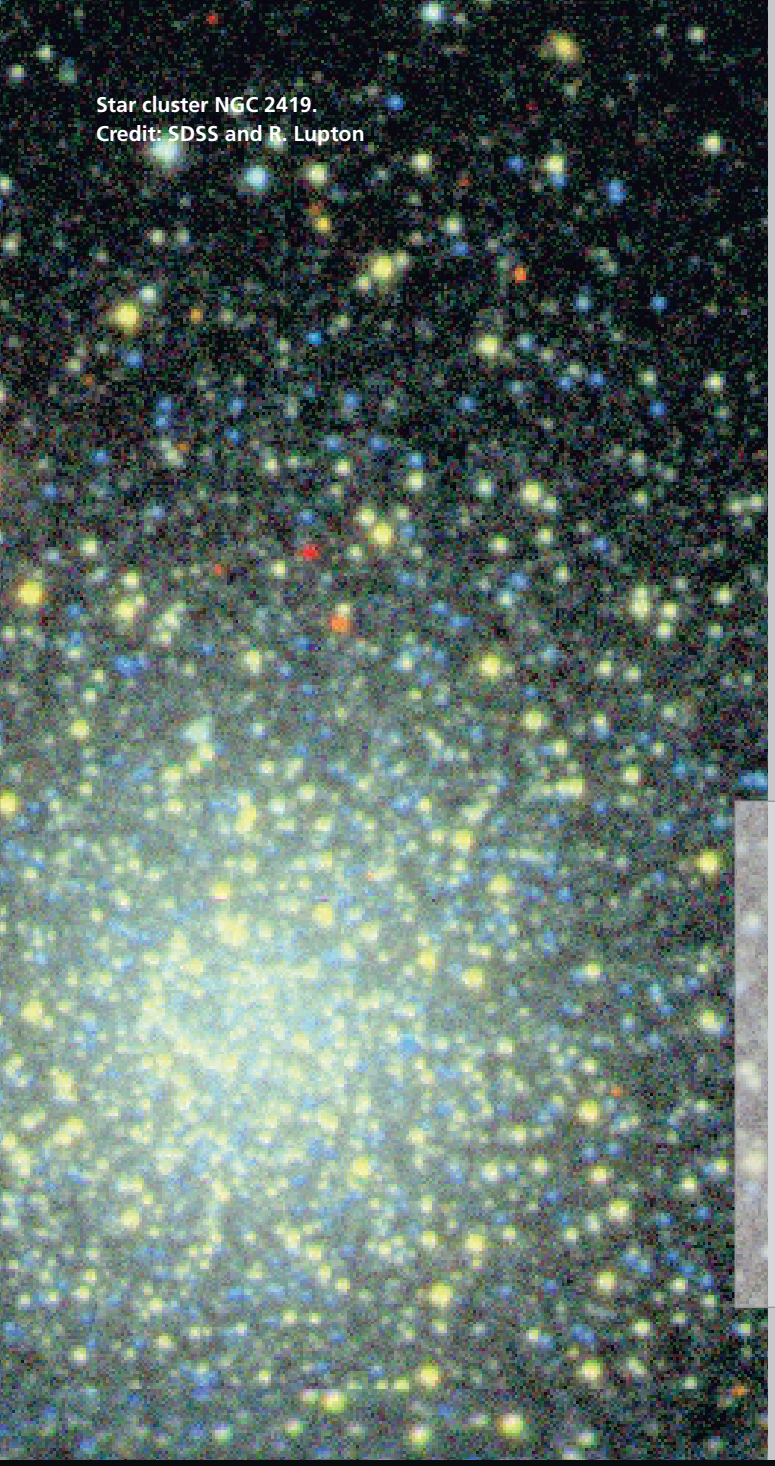
BOSS

BOSS AT A GLANCE:

- **Dark time observations, Fall 2009 – Spring 2014**
- **1,000-fiber spectrograph, resolution R~2000, wavelengths 360nm – 1000nm**
- **10,000 square degrees**
- **Redshifts of 1.5 million luminous galaxies to z = 0.7**
- **Lyman-α forest spectra of 160,000 quasars at redshifts 2.2<z<3**







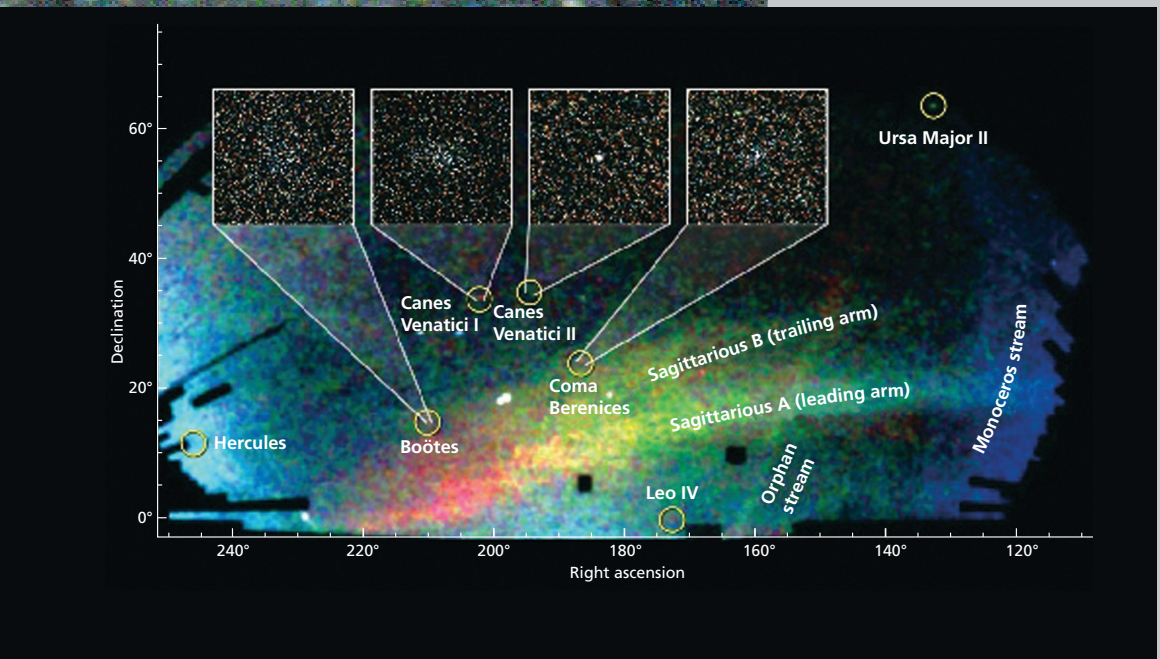
Star cluster NGC 2419.
Credit: SDSS and R. Lupton

SEGUE-2

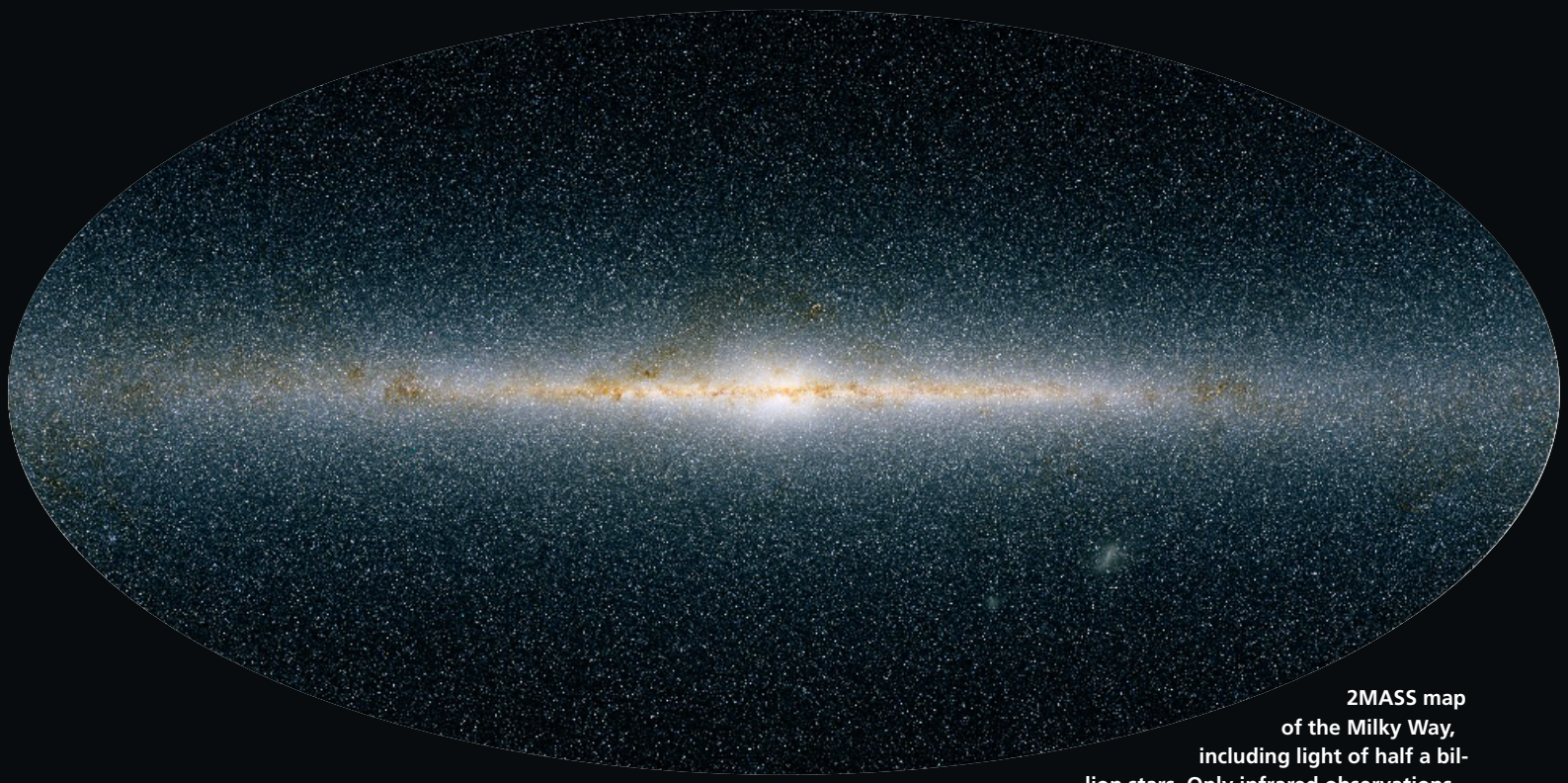
SEGUE-2 will map the outer Milky Way with spectra of 250,000 stars, doubling the sample of the SEGUE (Sloan Extension for Galactic Understanding and Exploration) component of SDSS-II. These measurements reveal the complex kinematic and chemical substructure of the Galactic halo and disks, providing essential clues to the assembly and enrichment history of the Galaxy. They uncover rare, chemically primitive stars that are fossils of the earliest generations of cosmic star formation.

SEGUE 2 AT A GLANCE:

- **Dark time observations, Fall 2008 – Spring 2009**
- **250,000 stars in multiple categories, to magnitude *g*=19**
- **Resolution R~2000, wavelengths 385nm – 920nm, typical S/N = 25**
- **Typical velocity error 4 km/s, [Fe/H] error 0.3 dex**
- **Bright time parallel program, 2010-2014 Additional 100,000 stars to *g*=17**



SDSS stellar map of the northern sky, showing trails and streams of stars torn from disrupted Milky Way satellites. Insets show new dwarf companions discovered by the SDSS.
Credit: V. Belokurov



2MASS map of the Milky Way, including light of half a billion stars. Only infrared observations penetrate to the dust-obscured inner Galaxy. *Credit: 2MASS, J. Carpenter, T. Jarret, R. Hurt*

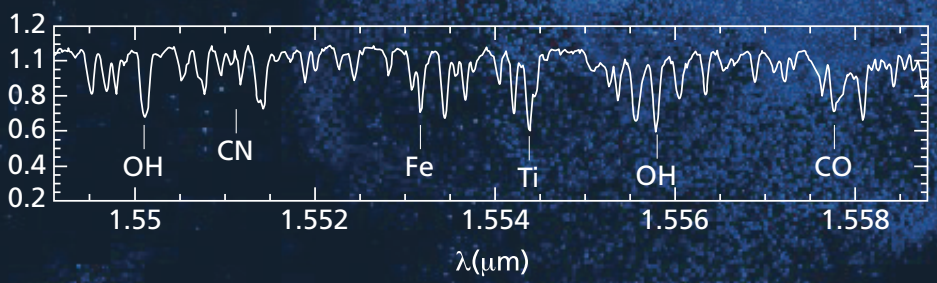
APOGEE

The APO Galactic Evolution Experiment will use high-resolution, high signal-to-noise, infrared spectroscopy to penetrate the dust that obscures the inner Galaxy from our view, with a survey of 100,000 red giant stars across the full range of the Galactic bulge, bar, disk, and halo. Precise radial velocities and detailed chemical abundance "fingerprinting" will provide unprecedented insights into the dynamical structure of the Galaxy and the star formation history and chemical enrichment pathways of its stellar populations. The SEGUE-2 and APOGEE data sets will play a central role in near-field cosmology tests of galaxy formation physics and the small-scale distribution of dark matter.

APOGEE AT A GLANCE:

- Bright time observations, Fall 2011 – Spring 2014
- 300-fiber cryogenic spectrograph, wavelengths 1.52 – 1.69 μm (*H*-band)
- Resolution R~20,000, typical S/N = 100
- Typical velocity error 0.5 km/s, abundances of more than 15 elements
- 100,000 2MASS-selected giant stars to *H* = 13.5, probing all Galactic populations

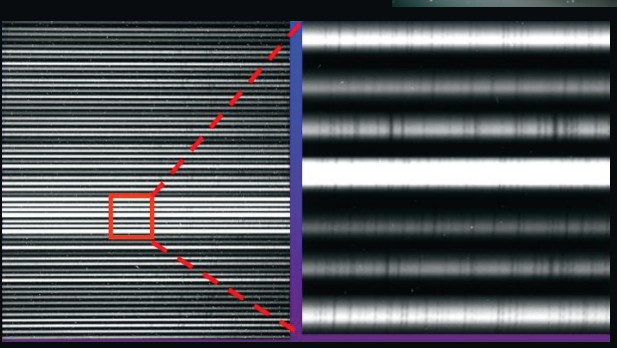
Below: Portion of a simulated *H*-band spectrum at APOGEE resolution. *Credit: R. Schiavon*

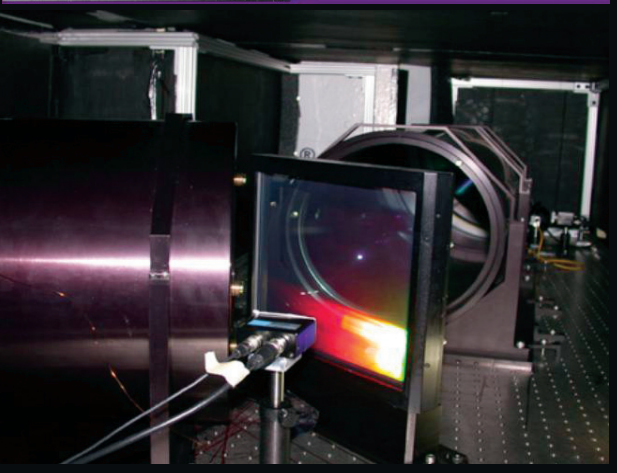


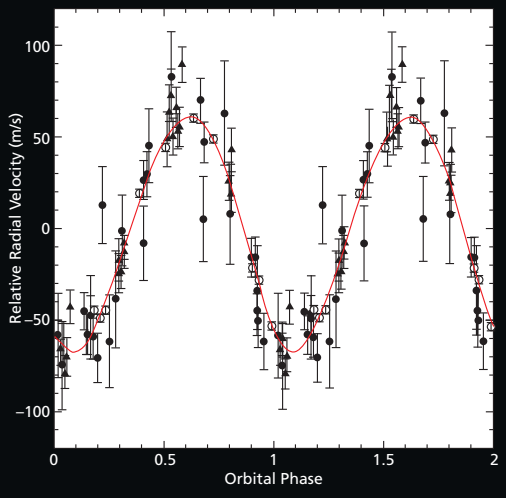
Background image: Star map of a simulated galaxy like the Milky Way. The network of low surface brightness trails reveals the galaxy's complex assembly history. *Credit: S. Sharma, K. Johnston, J. Bullock.*

Right: Artist's conception of an extra-solar planetary system. *Credit: T. Riecken*

Below: Spectra (top) from the Keck Exoplanet Tracker (middle) at APO, and radial velocity curve (bottom) of an extra-solar planet discovered by a prototype of the MARVELS spectrograph at Kitt Peak National Observatory.







MARVELS

The Multi-object APO Radial Velocity Exoplanet Large-area Survey will monitor the radial velocities of 11,000 bright stars, with the precision and cadence needed to detect gas giant planets that have orbital periods ranging from several hours to two years. With well-characterized sensitivity and a broad range of target star properties, MARVELS will provide a critical data set for testing theoretical models of the formation, migration, and dynamical evolution of giant planet systems. It will have unique sensitivity to rare systems such as extreme eccentricity planets or objects in the "brown dwarf desert."

MARVELS AT A GLANCE:

- **Bright time observations, Fall 2008 – Spring 2014**
- **Two 60-fiber interferometric spectrographs (one in initial phase)**
- **10,000 main sequence targets, 1,000 giant targets, V = 8-12**
- **25-35 observations per star over 18-month period**
- **Velocity error 12 m/s at V = 10**
- **Typical mass sensitivity at P = 100 days: 0.35 M_{Jup} (V = 9.5), 0.8 M_{Jup} (V = 11.5)**

Cover: SDSS image of the core of the Perseus galaxy cluster and redshift distribution in a thin slice through the SDSS main galaxy sample (yellow, green, cyan points) and luminous red galaxy sample (red points). *Credits: SDSS, R. Lupton, and M. Tegmark*

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